The Clenching-Grinding Spectrum and Fear Circuitry Disorders: Clinical Insights from the Neuroscience/ Paleoanthropology Interface

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Needs Assessment

The neuroevolutionary (distal) etiology of those fear-circuitry disorders which have a primarily musculoskeletal presentation has not been previously articulated. We present a neuroevolutionary etiology for one of the more common musculoskeletal pain syndromes, the clenching-grinding spectrum disorders. There is also a need to develop science-based interventions for the clenching-grinding spectrum disorders, since current interventions are invasive and not evidence-based. Finally, we propose that research should examine the possible utility of physical signs such as grinding and clenching as subcriteria of posttraumatic stress disorder Criterion D.

Target Audience

Neurologists and psychiatrists.

Learning Objectives

At the end of this activity, the participant should be able to:

- Consider adding to the initial neuropsychiatric office examination the palpation of the masticatory muscles and the inspection of the front incisors for the two proposed physical signs of stress-induced and fear-circuitry disorders.
- Explain to patients presenting with medically unexplained facial pain the postulated neuroevolutionary etiology of this spectrum of conditions and thus its link to the activation of fear-circuits and anxiety.

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Read this article, and the two CME-designated accompanying articles, reflect on the information presented, and then complete the CME quiz found on pages 327 and 328. To obtain credits, you should score 70% or better. Termination date: April 30, 2007. The estimated time to complete this activity is 3 hours.

ABSTRACT

This review discusses the clenching-grinding spectrum from the neuropsychiatric/neuroevolutionary perspective. In neuropsychiatry, signs of jaw clenching may be a useful objective marker for detecting or substantiating a self-report of current subjective emotional distress. Similarly, accelerated tooth wear may be an objective clinical sign for detecting, or substantiating, long-lasting anxiety. Clenching-grinding behaviors affect at least 8% of the population. We argue that during the early paleolithic

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environment of evolutionary adaptedness, jaw clenching was an adaptive trait because it rapidly strengthened the masseter and temporalis muscles, enabling a stronger, deeper and therefore more lethal bite in expectation of conflict (warfare) with conspecifics. Similarly, sharper incisors produced by teeth grinding may have served as weaponry during early human combat. We posit that alleles predisposing to fear-induced clenching-grinding were evolutionarily conserved in the human clade (lineage) since they remained adaptive for anatomically and mitochondrially modern humans (Homo sapiens) *well into the mid-paleolithic. Clenching-grinding, sleep bruxism, myofacial pain, craniomaxillofacial musculoskeletal pain, temporomandibular disorders, oro-facial pain, and the fibromyalgia/chronic fatigue spectrum disorders are linked. A 2003 Cochrane meta-analysis concluded that dental procedures for the above spectrum disorders are not evidence based. There is a need for early detection of clenching-grinding in anxiety disorder clinics and for research into science-based interventions. Finally, research needs to examine the possible utility of incorporating physical signs into* Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition *posttraumatic stress disorder diagnostic criteria. One of the diagnostic criterion that may need to undergo a revision in* Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition *is Criterion D (persistent fear-circuitry activation not present before the trauma). Grinding-induced incisor wear, and clenching-induced palpable masseter tenderness may be examples of such objective physical signs of persistent fear-circuitry activation (posttraumatic stress disorder Criterion D).*

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INTRODUCTION

Jaw clenching-teeth grinding behavior is a little studied area of interface between craniomaxillofacial surgery, and neurobiology. This review highlights the interface among research on fear and distress, craniomaxillofacial musculoskeletal syndromes, and paleo-anthropology. We contend that understanding musculoskeletal craniomaxillofacial syndromes in this context has immediate evidence-based clinical implications that are infrequently applied.

THE CLENCHING-GRINDING SPECTRUM: A BRIEF OVERVIEW OF RELEVANT NEUROBIOLOGY

Jaw clenching, spasmodic nonfunctional gnashing, teeth grinding, sleep bruxism, and spontaneous rhythmic masticatory muscle activity (RMMA) during sleep are all closely related, overlapping conditions.[1,2] The particular diagnostic label seems to depend mostly on the specialist consulted.

Only recently has the attention of researchers shifted away from dental factors and toward neurobiological factors in the etiology of clenching-grinding spectrum disorders.[1] Case reports of patients with brainstem and cortical strokes and lesion studies in laboratory animals[3] have implicated primarily the reticular pontis oralis nucleus and pontis caudalis nucleus, as well as the parvocellular nucleus in the clenching-grinding spectrum.[3] The neurotransmitter most clearly implicated in the initiation or exacerbation of clenching-grinding spectrum disorders is primarily norepinephrine (NE) but also include glutamate and dopamine.[3-7] In contrast, γ-aminobutyric acid (GABA) signaling may have a beneficial effect.[3] The role of serotonin is complex and awaits clarification by knockout mice studies.

Teeth grinding during sleep (sleep bruxism) is the most-studied segment within the clenching-grinding spectrum. Sleep bruxism is the oro-motor manifestation of micro-arousal.[2] Sleep bruxism occurs primarily during sleep-stage shifts. In patients with sleep bruxism, a sequence of cortical-to-autonomic cardiac activation precedes jaw motor activity. Sleep RMMA occurs in relation to transient activation of cortical, limbic and autonomic circuits both in patients with sleep bruxism and in controls. Heart rate significantly accelerates one cardiac cycle just prior to RMMA onset.[2]

In the Stanford University self-report survey[8] of >13,000 participants using the Sleep-EVAL knowledge-based system, 4.4% of the sample met diagnostic criteria for sleep bruxism while 8% met the less-restricted diagnosis of teeth grinding. The lifetime prevalence of the whole clenching-grinding spectrum is unclear primarily due to varying definitions in different studies, but is suspected to be several times higher.

In the aforementioned survey of >13,000 participants, factors associated with a higher risk for reporting sleep bruxism included anxiety (odds ratio [OR]: 1.3), "a highly stressful life" (OR: 1.3), alcohol consumption (OR: 1.8), smoking (OR: 1.3), and consumption of >6 cups of caffeinated coffee/day (OR: 1.4).[8] Other conditions associated with a higher risk for reporting sleep bruxism include daytime automatisms, hypnopompic or hypnogogic hallucinations, injurious or violent sleep behaviors, sleep talking, daytime sleepiness, loud snoring, and sleep apnea.[8] Sleep bruxism and presumably other clenching-grinding behaviors peak between 25 and 44 years of age.[8] It is of note that this is similar to the age range in which the prevalence of most anxiety disorders peak.

JAW CLENCHING AND TEETH GRINDING: A NEURO-EVOLUTIONARY PERSPECTIVE

Very little has been written from a neuroevolutionary perspective about jaw clenching behaviors. Although we have not found this articulated in the literature, we propose that the evolutionary purpose of jaw clenching may simply be the strengthening of the masticatory (bite) muscles.

Prior to the discovery of fire making, strong masticatory (bite) muscles may have facilitated food consumption and, thus, survival for early genus homo. Probably more importantly, in the early paleolithic environment of evolutionary adaptedness (EEA) (~2 million–200,000 years ago), jaw clenching rapidly strengthened the two primary muscles involved in biting—the masseter muscles and the much larger temporalis muscles—and may have served the purpose of enabling a stronger, deeper, and therefore more lethal, defensive bite.

While it was traditionally assumed that the origin of human warfare is relatively recent, more careful, newer research has documented extensive warfare in the early paleolithic (early pleistocene) EEA. Long periods of genus homo evolution were characterized by frequent lethal intraclan and interclan violence.[9-12] For more recent discussions of paleolithic intra-human killing and of the myth of the "noble savage," see recent reviews.[13-19] Throughout the EEA and as recently as 1000 CE, the majority of combat deaths did not occur on the battlefield. Instead, research strongly suggests that combat deaths resulted from infection of injuries due to the inability to treat most infected wounds.[20,21]

Some paleolithic skeletons show little bone damage other than human teeth marks. While there are other explanations, these teeth marks may suggest lethal interpersonal ancestral violence involving actual human bites. Human bites have been shown to be among the most lethal mammalian bites due to the particular nature of the human oral flora. If deep enough and left untreated, human bites have a very high mortality rate.[22] We hypothesize that clenching, by exercising the bite muscles, provided an improved defensive bite within days for the paleolithic combatant. This is an order of magnitude faster than could be achieved by incisor enamel sharpening (which takes weeks or months).

While jaw clenching in other species has been little studied, incisor grinding has been well-documented in baboons and other primates, as well as in several species closely related to primates, such as rats.[23]

A hypothesis related to our jaw clenching hypothesis has been proposed for incisor grinding by Every[24] and recently expanded upon by Kleinberg[25] and Murray and Sanson.[26] These Australian research dentists have argued that constantly sharpened incisors may have been an adaptive survival trait for the paleolithic combatant. This behavioral trait may have been evolutionarily conserved, and may be the basis, for clinical teeth grinding.[23-27] While dental academic tertiary care centers typically see the tooth flattening (shortening) associated with late-stage advanced bruxism, we contend that the sharpening function of grinding is much clearer at earlier stages prior to the enamel chipping and dentin loss that eventually shortens and flattens the incisors. The increased chipping of the incisors is a natural consequence of the heightened fragility of the sharpened incisors' edge due to the thinning of the enamel. We posit that family dentists, military dentists treating active duty personnel, and anxiety disorders specialists are much more likely to see patients at the earlier "sharp incisors stage".[28] This changing clinical presentation is in some way analogous to the changing clinical presentation of some thyroid disorders, which progress from early adulthood hyperthyroidism to mid-life hypothyroidism. This changing clinical presentation also may be somewhat analogous to an anxiety-depression spectrum disorder progressing from early-life anxiety (with normal or elevated pain threshold) to late-life depression (with a diminished pain threshold).

Human longevity during the paleolithic era was usually too short to allow the development of advanced tooth wear resulting from grinding or in disabling masticatory muscle disorders from jaw clenching. However, the line of reasoning reviewed in the previous paragraph strongly supports the conclusion that clenching and grinding may primarily be a manifestation of experiencing acute fear or chronic emotional distress, respectively. We posit that the alleles, which wire the fear circuits to the brainstem nuclei activating the clenching-grinding behaviors were highly conserved in the human clade (lineage), since they remained highly adaptive for anatomically and mitochondrially modern humans well into the mid-paleolithic.

TEMPORAL-LIMBIC ACTIVATION AND JAW CLENCHING

While there is a fair amount of literature on bruxism, almost nothing has been written about the more common jaw clenching. Jaw clenching is often unnoticed by the anxious patient until it is pointed out by a neuropsychiatrist. Although nothing has been published about these phenomena in the pediatric, mental retardation, or autism spectrum disor-

ders literature, striking displays of intense, prolonged jaw clenching can be clinically observed during fear or rage in developmentally disabled individuals (and may be mistaken for dystonia).

Additionally, striking displays of jaw clenching can also be seen in preverbal healthy toddlers, which may also be a manifestation of fear or rage in the preverbal period. It is of note that during the early paleolithic, the genus Homo was still completely preverbal.[11,13,14,17,18] Future research can confirm or disconfirm the clinical observation that such clenching displays, both in patients with mental retardation and in healthy preverbal toddlers, precede actual biting of others usually within a few days.

Finally, anecdotal data from emergency departments suggest that physically assaulted individuals, and especially sexually assaulted individuals, may use biting as a means of self-defense.[22] This may be relevant in the psychiatric assessment of individuals presenting in emergency departments with severe human bites, especially to the head and neck.

TEMPORAL-LIMBIC STRUCTURES AND JAW CLENCHING

We posit a second role for jaw clenching in the distressed/anxious individuals based on recent literature.[29] We hypothesize that jaw clenching increases the blood flow to anterior temporal lobe structures during acute activation of the limbic fear circuits. Jaw clenching may increase the blood flow to temporal lobe structures by pumping blood through the temporal bone emissary veins, thus conferring a possible survival advantage during activation of the limbic fear-circuits in expectation of situations requiring the freeze, flight, fight, fright acute fear response.[18,19,30] This is consistent with new research, [29,31-33] which demonstrates a possible beneficial affect of masticatory movements (eg, non-nutritive chewing) on both hippocampal function and hippocampal structures.

POSSIBLE IMPLICATIONS FOR THE DIAGNOSTIC AND STATISTICAL MANUAL OF MENTAL DISORDERS, FIFTH EDITION

Assessment Implication: "Hard to Hide" and "Hard to Fake" Physical Signs of Stress and Anxiety

In addition to shifting focus from disorders to spectrums, future editions of the *Diagnostic and Statistical Manual of Mental Disorders* (such as the forthcoming *Diagnostic and Statistical Manual of Mental Disorders-Fifth Edition* [DSM-V])[34] may opt to include a larger number of physical examination signs in the "Associated Physical Examination Findings" sections of the text and possiblly as subcriteria for the diagnoses of some *DSM-V* disorders. Assessments of anxiety spectrum disorders currently depends almost exclusively on retrospective self-report. Extensive psychometric literature has demonstrated that paper and pencil instruments (particularly questionnaires and also structured interviews) for trait anxiety and recent subjective distress can be highly vulnerable to both over-reporting[35-37] and under-reporting.[37-42] This diminishes both the positive predictive value and the negative predictive value of questionnaires and structured interviews.

We posit that easily observable physical signs, such as incisor tooth wear, may augment the clinical assessment of fear-circuitry disorders such as posttraumatic stress disorder (PTSD). In clinical psychiatric settings, objective physical "hard to hide" signs of stress-induced and fear-circuitry disorders are rare. Wear of the incisors' enamel invariably results from chronic grinding and may be one such hard to hide sign. Clinicians practicing in settings where individuals tend to under-report symptoms due to stigma, cultural, or other reasons, may especially benefit from hard-to-hide indicators of under-reported anxiety. These include the Japanese culture-bound genomes as well as most other Asian and Pacific Islander ethnic groups.[43,44] Self-imposed cultural barriers of access to mental healthcare may also exist in other "bushido" (warrior) male cultures. The United States Armed Forces active duty-enlisted personnel appears to be another American subculture that under-reports emotional distress due to stigma and deep-rooted beliefs about masculinity. This can impede clinical assessment (eg, suicide risk), early intervention, and primary prevention.[43-45]

Furthermore, incisor tooth wear is also a "hard-to-fake" indicator of anxiety. Such objective signs are much needed in the clinical armamentarium in settings, such as litigation and compensation and substance abuse treatment centers where patients may over-report anxiety symptoms. Assessment of observable signs of clenching-grinding can be easily incorporated into the examination of the anxious patient in psychiatric medicine and general medical settings, as well as in substance abuse settings.

Even before tooth wear is noted in incisors, bilateral hypertrophy and tenderness of the masseter and especially the temporalis muscle can often be identified by inspection and palpation in acutely distressed patients unaware of their clenching habit.

OTHER RESEARCH IMPLICATIONS

In the anxiety and stress disorder literature, discussions of jaw clenching are rare. However, case reports of intense jaw clenching in individuals abusing substances,[4-7,46,47] which increases NE, glutamate, or dopamine signaling, are not uncommon. Research may be warranted on the complex role of serotonin receptor subtypes in the clenching-grinding spectrum. The (often transient) jaw clenching that patients frequently report during initiation of the selective serotonin reuptake inhibitors is not well-understood. De-novo appearance of clenching, worsening of preexisting clenching, and, occasionally, amelioration of preexisting clenching have been clinically observed. This type of clenching has been little studied. The course of clenching prior to and during antidepressant treatment is unknown. Based on the available stimulant abuse and stroke literature cited above, we submit that the final common pathways of jaw clenching are primarily the increased signaling in the brainstem NE neurons, especially when combined with still non-downregulated receptors. Furthermore, clenching may serve as a rough clinical proxy for elevated NE signaling. However, as stated above, future research using knockout mice may help clarify the possible role of serotonin receptor subtypes. Additionally, we suggest that clenching may also have some potential as an endophenotype in PTSD research.

Implications for the Psychiatric Management of Anxiety

While a custom-made intraoral protective occlusal splint ("night-guard") for clenching and grinding does appear to be a face-valid logical approach to preventing tooth wear (enamel loss), there are no published randomized controlled trials (RCT) documenting its effectiveness or efficacy for the prevention of clenching and its complications.

Based on anecdotal data suggesting favorable response, low-dose tricyclic antidepressants (TCAs), are usually prescribed by dentists for severe clenching-grinding behaviors and chronic facial pain. There are no published RCTs in this area and more research is needed. The xerostomia produced by traditional TCAs appears to limit compliance with these medications, especially in this patient population, since xerostomia tends to further increase jaw movement. Other psychopharmacologic options may need to be explored. Early intervention with low doses of antidepressants that have fewer side effects or low doses of other medications suitable for long-term management of anxiety should also be studied for severe clenching–grinding spectrum behaviors. Only recently has cognitive-behavioral therapy (CBT) been studied for the treatment of advanced temporomandibular disorder (TMD). Results are encouraging.[48] However, there are no published studies of CBT for the clenching-grinding spectrum aimed at preventing progression to TMD.

In addition to providing appropriate management of any underlying anxiety spectrum disorder, an increased index of suspicion for subsequent TMD; is also warranted. As articulated in a recent review from the Bethesda Naval Hospital School of Dentistry, the dental nomenclature for TMD has recently been updated[49]:

"Temporomandibular disorders (TMD) is a collective term that describes a number of clinical complaints involving the muscles of mastication, temporomandibular joints (TMJ), and associated orofacial structures. Previous terms include Costen syndrome, TMJ dysfunction, and craniomandibular disorders. TMD is a major cause of nondental pain in the orofacial region and is considered a sub-classification of musculoskeletal disorders. In many TMD patients, the most common complaint is not the TMJ but rather the muscles of mastication. Therefore the terms 'TMJ dysfunction' and 'TMJ disorder' are inappropriate for many of these complaints. For this reason, the American Dental Association adopted the more general term, Temporomandibular disorders."[49]

Masticatory muscle disorders (MMDs) (also known as extra-capsular TMD) are the largest subcategory (~60%) of TMD. MMDs present as tenderness of the temporalis and masseter muscles. MMDs almost always precede arthropathic (intracapsular) injury to the temporomandibular joint (TMJ) cartilage. Low-dose TCAs, and increasingly carbamazepine, phenytoin, and glutamate-release inhibitors are used for MMDs.[50] It is of note that RCTs have not been conducted and there are no Food and Drug Administration-approved pharmacologic interventions for this spectrum of disorders.

However, patients reporting clenching and grinding readily accept the suggestion (based on the reasoning and evidence reviewed above) that clenching, grinding, and sleep bruxism may be markers of a tendency to react to emotional distress with muscle tensing.

HEALTH SERVICE AND CLINICAL RESEARCH IMPLICATIONS

While rarely addressed by non-dentists, TMD is common in the dental office. "With regard to pain, these conditions are second only to odontalgia (ie, tooth or periodontal pain) in terms of frequency."[49] The overall cost of current dental and surgical interventions to prevent or treat TMD is unknown.[28,51]

Occlusal Adjustments are not Effective for Clenching-Grinding and Related Disorders

A common dental primary care procedure (non-orthodontic) often used for the elimination of audible sleep bruxism is occlusal adjustment.[51,52] Occlusal adjustment is the removal (iatrogenic grinding) of enamel in selected areas. Occlusal adjustment silences audible night bruxing but accelerates enamel wear.[52] A 1995 review of the literature by Vanderas and Manetas[52] concluded that occlusal adjustment to prevent or treat clenching-grinding is not supported by longitudinal studies and is not scientifically justified. Furthermore, a 2003 Cochrane Database meta-analysis by Koh and Robinson[51] assessing the effectiveness of occlusal adjustment for treating and preventing TMD in adults concluded that occlusal adjustment is not an evidence-based procedure for the treatment or prevention of TMD.

Stress-induced clenching has been especially neglected in the literature. We were unable to find published studies on the management of clenching. Jaw clenching, as a risk factor for craniomaxillofacial pain, may need more focused research. Clenching usually precedes teeth grinding and may be the earliest manifestation of the "acute-emotional distress to chronic facial pain cascade" discussed above.[28] Unlike teeth grinding, which is often audible to others, clenching is a "silent" behavior. In contemporary populations, only dentists attempt to address clenching. However, as previously stated, neither the effectiveness nor the efficacy of dental interventions for clenching-grinding and for the prevention or amelioration of TMD have been established with RCTs.

Orthodontic Procedures are Contraindicated for Clenching-Grinding and Temporomandibular Disorders

Dental malocclusion (sub-optimal intercuspation of the teeth) was previously assumed to be the major factor in the etiology of clenching-grinding. Therefore, until recently, high-cost orthodontic procedures (braces) were prescribed in the United States for clenching-grinding in an attempt to prevent the progression to TMD. This approach to managing clenching-grinding is not evidence-based. Although still occasionally practiced by private sector dentists in the US, braces, solely for the prevention of clenching-grinding and TMD, are now considered by the leading authorities[53] to be contraindicated and may constitute malpractice.

Once TMD is diagnosed, current dental interventions are invasive and palliative. These include laser irradiation of the joint and muscles, acupuncture, intra-capsular injections of corticosteroids or joint lubricants, and temporomandibular joint surgical implants.[28,50] No RCT data exist for any of the current dental interventions for the TMD disorders. When surgical implants fail to relieve the pain, opiates are still widely used in dentistry for TMD.[50]

NIH recommendations for TMD management have not changed since the 1996 National Institutes of Health Technology Assessment Conference Statement: Management of Temporomandibular Disorders,[53] which stated:

"The vast majority of TMD patients should receive initial management using noninvasive and reversible therapies...The efficacy of most treatment approaches for TMD is unknown, because most have not been adequately evaluated in long-term studies and virtually none in randomized controlled group trials...Therapies that permanently alter the patient's occlusion cannot be recommended on the basis of current data... Relaxation and cognitive behavioral therapies are effective approaches to managing chronic pain...".[53]

COMORBIDITY WITH OTHER STRESS-INDUCED DISORDERS

As part of the landmark University of Washington monozygotic co-twin control study of chronic fatigue syndrome, Aaron and Buchwald[54] reviewed the overlap between chronic fatigue syndrome, fibromyalgia and TMD. In hospital-based clinics, patients diagnosed with TMD, chronic fatigue syndrome, and fibromyalgia share common symptoms, including heightened pain sensitivity and concentration difficulties.[55] The Seattle monozygotic co-twin control study suggests that patients with both masticatory muscle (extra-capsular) and arthropathic (intra-capsular cartilage) TMD share many clinical features with fibromyalgia and chronic fatigue syndrome, such as impairment in ability to perform activities of daily living (ADL), including those ADL that are not related to mastication.[56,57]

The hypoalgesia associated with the freeze,flight-fight, fright response of acute fear[19,30] may seem at odds with the hyperalgesia associated with TMD and fibromyalgia. This apparent contradiction may be resolved by consideration of the effects of chronic hypervigilance on locus coeruleus (LC) NE neurons. Chronic hypervigilance may result in accelerated aging or "overuse injury" to the LC, and thus "burning-out" of the LC neurons following inescapable stress. This is also supported by our postmortem study of the LC in war-related PTSD, which found a decrease in LC neuronal count approaching 30%.[58]

Additionally, recent literature suggests that other chronic pain disorders commonly coexist in patients with TMD (eg, irritable bowel syndrome, chronic pelvic pain, and migraine headaches).[56] More theory-based, longitudinal, and prospective research on stress-induced clenching-grinding may also clarify the possible positive predictive value of clenching-grinding for midlife-onset muscle pain syndromes and for some adult-onset mood disorders.

IMPLICATIONS FOR POSTTRAUMATIC STRESS DISORDER RESEARCH

In veterans with PTSD and other post-deployment disorders an especially high prevalence of clenching-grinding behaviors has been clinically observed. Research is needed to explore the possible positive predictive value of pre-deployment and post-deployment clenching-grinding with regard to PTSD and other related disorders. Bracha and colleagues[43-45] have also argued that in patients with PTSD and in individuals with post-deployment medically unexplained symptoms, the development of physical markers of pre- and post-deployment anxiety may greatly facilitate implementation of science-based treatment guidelines.

Andreasen[59] has recently noted that "the concept of PTSD took off like a rocket, and in ways that had not initially been anticipated." She proposed that the broadening of Criterion A of PTSD in *DSM-IV* (compared with *DSM-III-R*) "should be reconsidered".[59] Similar arguments were recently made in a white paper for A Research Agenda for *DSM-V*.[60] Bracha and colleagues[43] and Bracha and colleagues[44] have also argued that the incorporation of simple, objective physical signs into Criterion A of PTSD (as a subcriterion A3) may greatly increase the clinical usefulness of Criterion A of PTSD. Another diagnostic Criterion of PTSD that is likely to undergo a revision in *DSM-V* is Criterion D (persistent fear-circuitry activation not present before the trauma). Based on the literature reviewed in this article, we propose that research towards the forthcoming *DSM-V* should examine the possible utility of incorporating observable grinding and palpable tenderness of the masticatory muscle as subcriteria of PTSD Criterion D.

We put forward that the neuroevolutionary model we describe above suggests that psychiatric interventions for the clenching-grinding spectrum should begin very early and before facial pain (or severe tooth wear) develops. This will require detection of clenching-grinding behaviors at the earliest stages. This may be achieved in settings, such as in anxiety disorder and PTSD clinics.

Finally, in light of recent PTSD treatment studies by Pitman and colleagues[61] and Raskind and colleagues,[62] it may be of interest to examine the relative role of α versus β noradrenergic receptors on clenching-grinding spectrum disorders.

CONCLUSION

In the US, jaw clenching and teeth grinding lead to high dental restoration costs and often to chronic craniomaxillofacial pain. High-cost orthodontic and surgical procedures have now been shown to be ineffective in preventing or treating TMD and are considered contraindicated. The progression from stress-induced clenching-grinding to TMD, and possibly to more severe muscle pain syndromes, is suggested by recent research. Patients with any of these disorders share common key symptoms and probably common underlying neurobiological and neuroevolutionary mechanisms. Furthermore, a temporal relationship among these disorders is increasingly supported by research. This may suggest a cascade of anxiety-based disorders of increasing severity. The direct and indirect healthcare costs of treating or not treating the spectrum, which usually begins with jaw clenching, is unknown. Early attention to the clenching-grinding spectrum as an objective physical sign of underlying distress, either acute or chronic, may be a neglected aspect in psychiatric medicine. Visually inspecting anxiety disorder patients' incisors for severe enamel wear can be easily incorporated into the initial examination in PTSD and other anxiety disorder clinics. Furthermore, palpation of the temporalis and masseter for clenching-induced bilateral tenderness can also be incorporated into the physical examination component of psychiatric assessment. Research should examine the possible utility of observable grinding and palpable masticatory muscle tenderness as subcriteria of a revised Criterion D of PTSD. CNS

REFERENCES

1. Lobbezoo F, Naeije M. Bruxism is mainly regulated centrally, not peripherally. *J Oral Rehabil.* 2001;28:1085-1091.
2. Kato T, Rompre P, Montplaisir JY, Sessle BJ, Lavigne GJ. Sleep bruxism: an oromotor activity secondary to micro-arousal. *J Dent Res.* 2001;80:1940-1944.
3. Lavigne GJ, Kato T, Kolta A, Sessle BJ. Neurobiological mechanisms involved in sleep bruxism. *Crit Rev Oral Biol Med.* 2003;14:30-46.
4. Winocur E, Gavish A, Volfin G, Halachmi M, Gazit E. Oral motor parafunctions among heavy drug addicts and their effects on signs and symptoms of temporomandibular disorders. *J Orofac Pain.* 2001;15:56-63.
5. Gomez FM, Areso MP, Giralt MT, Sainz B, Garcia-Vallejo P. Effects of dopaminergic drugs, occlusal disharmonies, and chronic stress on non-functional masticatory activity in the rat, assessed by incisal attrition. *J Dent Res.* 1998;77:1454-1464.
6. Milosevic A, Agrawal N, Redfearn P, Mair L. The occurrence of toothwear in users of Ecstasy (3,4-methylenedioxymethamphetamine). *Community Dent Oral Epidemiol.* 1999;27:283-287.
7. See SJ, Tan EK. Severe amphethamine-induced bruxism: treatment with botulinum

toxin. *Acta Neurol Scand.* 2003;107:161-163.
8. Ohayon MM, Li KK, Guilleminault C. Risk factors for sleep bruxism in the general population. *Chest.* 2001;119:53-61.
9. Roper MK. A survey of the evidence for intrahuman killing in the Pleistocene. *Current Anthropology.* 1969;10:427-459.
10. Ortner DJ, Putschar WGJ. *Identification of Pathological Conditions in Human Skeletal Remains.* Washington, DC: Smithsonian Institution Press; 1985.
11. Tattersall I. *Becoming Human: Evolution and Human Uniqueness.* Orlando, FL: Harcourt Brace & Company; 1998.
12. Buss DM. *Evolutionary Psychology: The New Science of the Mind.* Boston, Mass: Allyn and Bacon; 1999.
13. LeBlanc SA, Register KE. *Constant Battles: The Myth of the Peaceful, Noble Savage.* New York, NY: St. Martin's Press; 2003.
14. Marcus G. *The Birth of the Mind: How a Tiny Number of Genes Creates the Complexities of Human Thought.* New York, NY: Basic Books; 2004.
15. Hillson S. *Dental Anthropology.* Cambridge, UK: Cambridge University Press; 1996
16. Larsen CS. *Bioarchaeology: Interpreting Behavior From the Human Skeleton.* 1st ed. Cambridge, UK: Cambridge University Press; 1999.
17. Klein RG, Edgar B. *The Dawn of Human Culture.* New York, NY: Nevraumont Publishing Company; 2002.
18. Bracha HS, Bracha AS, Williams AE, Ralston TC, Matsukawa JM. The human fear-circuitry and fear-induced fainting in healthy individuals: the paleolithic-threat hypothesis. *Clin Auton Res.* In press.
19. Bracha HS. Freeze, flight, fight, fright, faint: adaptationist perspectives on the acute stress response spectrum. *CNS Specrr.* 2004;9:679-685.
20. Lacey R, Danziger D. *The Year 1000: What Life Was Like at the Turn of the First Millennium.* New York, NY: Little, Brown and Company; 1999.
21. Salazar CF. *The Treatment of War Wounds in Graeco-Roman Antiquity (Studies in Ancient Medicine).* Vol. 21 Boston, Mass: Brill Academic Publishers; 2000.
22. Pretty IA, Hall RC. Forensic dentistry and human bite marks: issues for doctors. *Hosp Med.* 2002;63:476-482.
23. Bracha HS, Blanchard DC, Lloyd-Jones JL, Williams AE, Blanchard RJ. Experimental combat-stress model in rats: histological examination of effects on amelogenesis—a possible measure of diminished vagal tone episodes. *Dental Anthropology.* 2004;17:79-82.
24. Every RG. Significance of tooth sharpness for mammalian, especially primate, evolution. *Contrib Primatol.* 1975;5:293-325.
25. Kleinberg I. Bruxism: aetiology, clinical signs and symptoms. *Aust Prosthodont J.* 1994;8:9-17.
26. Murray CG, Sanson GD. Thegosis–a critical review. *Aust Dent J.* 1998;43:192-198.
27. Bracha HS. Fears, anxieties, phobias, and hypophobias: proposed neuroevolutioary etiologies of firm-wired (prepotent) fear-circuitry syndromes. *Prog Neuropsychopharmacol Biol Psychiatry.* In press.
28. Bracha HS, Williams AE, Person DA, Ralston TC, Yamashita JM, Bracha AS. Reevaluating the management of chronic temporomandibular pain: are we treating PTSD with debridement and lavage? *Fed Prac.* 2004;21:50-52.
29. Farella M, Bakke M, Michelotti A, Marotta G, Martina R. Cardiovascular responses in humans to experimental chewing of gums of different consistencies. *Arch Oral Biol.* 1999;44:835-842.
30. Bracha HS, Ralston TC, Matsukawa JM, Williams AE, Bracha AS. Does "fight or flight" need updating? *Psychosomatics.* 2004;45:448-449.
31. Yamamoto T, Hirayama A. Effects of soft-diet feeding on synaptic density in the hippocampus and parietal cortex of senescence-accelerated mice. *Brain Res.* 2001;902:255-263.
32. Onozuka M, Watanabe K, Mirbod SM, et al. Reduced mastication stimulates impairment of spatial memory and degeneration of hippocampal neurons in aged SAMP8 mice. *Brain Res.* 1999;826:148-153.
33. Wilkinson L, Scholey A, Wesnes K. Chewing gum selectively improves aspects of memory in healthy volunteers. *Appetite.* 2002;38:235-236.
34. Charney DS, Barlow DH, Botteron KN, et al. Neuroscience research agenda to guide development of a pathophysiologically based classification system. In: Kupfer DJ, First MB, Regier DA, eds. *A Research Agenda for DSM-V.* Washington, DC: American Psychiatric Association; 2002:31-83.
35. Loftus E. Our changeable memories: legal and practical implications. *Nat Rev Neurosci.* 2003;4:231-234.
36. Loftus EF, Cole SA. Contaminated evidence. *Science.* 2004;304:959.
37. McNally RJ. *Remembering Trauma.* Cambridge, Mass: The Belknap Press of Harvard University Press; 2003
38. Sarwer DB, Sayers SL. Behavioral interviewing. In: eds, Bellack AS, Hersen M. *Behavioral Assessment: A Practical Handbook.* 4th ed. Needham Heights, Mass: Allyn and Bacon; 1998:63-78.
39. Segal DL, Falk SB. Structured interviews and rating scales. In: Bellack AS, Hersen M, eds. *Behavioral Assessment: A Practical Handbook.* 4th ed. Needham Heights, Mass: Allyn and Bacon; 1998:158-178.
40. Aiken LR. *Questionnaires and Inventories: Surveying Opinions and Assessing Personality.* New York, NY: John Wiley & Sons, Inc.; 1997.
41. Haynes SN, Lench HC. Incremental validity of new clinical assessment measures. *Psychol Assess.* 2003;15:456-466.
42. Miller TW. Current measures in the assessment of stressful life events. In: ed, Miller TW. *Theory and Assessment of Stressful Life Events.* Madison, CT: International Universities Press: 1996:209-233
43. Bracha HS, Williams AE, Haynes SN, Kubany ES, Ralston TC, Yamashita JM. The STRS (shortness of breath, tremulousness, racing heart, and sweating): a brief checklist for acute distress with panic-like autonomic indicators; development and factor structure. *Ann Gen Hosp Psychiatry.* 2004;3:8.
44. Bracha HS, Williams AE, Ralston TC. Criterion-A of PTSD: a brief symptom checklist for disaster-aftermath screening. *Curr Psychiatry.* 2005;4:40-43.
45. Bracha HS, Yamashita JM, Ralston TC, et al. Clinical research histomarkers for objectively estimating premorbid vagal tone chronology in gulf war veterans' illnesses and in acute stress reaction. In: eds, Nation J, Trofimova I, Rand JD, Sulis W. *Formal Descriptions of Developing Systems (NATO Science Series).* Dordrecht, Netherlands: Kluwer Academic Publishers; 2003:279-288.
46. Richards JR, Brofeldt BT. Patterns of tooth wear associated with methamphetamine use. *J Periodontol.* 2000;71:1371-1374.
47. Nixon PJ, Youngson CC, Beese A. Tooth surface loss: does recreational drug use contribute? *Clin Oral Investig.* 2002;6:128-130.
48. Sherman JJ, Turk DC. Nonpharmacologic approaches to the management of myofascial temporomandibular disorders. *Curr Pain Headache Rep.* 2001;5:421-431.
49. Imamura Y, Okeson JP. Diagnosis of chronic orofacial pain. In: Dionne RA, Phero JC, Becker DE, eds. *Management of Pain and Anxiety in the Dental Office.* St. Louis, Mo: W.B. Saunders Company; 2002:337-353.
50. Ta LE, Neubert JK, Dionne RA. Pharmacologic treatments for temporomandibular disorders and other orofacial pain. In: Dionne RA, Phero JC, Becker DE, eds. *Management of Pain and Anxiety in the Dental Office.* St. Louis, Mo: W.B. Saunders Company; 2002:354-367.
51. Koh H, Robinson PG. Occlusal adjustment for treating and preventing temporomandibular joint disorders. *Cochrane Database Syst Rev.* 2003;CD003812.
52. Vanderas AP, Manetas KJ. Relationship between malocclusion and bruxism in children and adolescents: a review. *Pediatr Dent.* 1995;17:7-12.
53. Management of temporomandibular disorders. National Institutes of Health Technology Assessment Conference Statement. *J Am Dent Assoc.* 1996;127:1595-1606.
54. Aaron LA, Buchwald D. A review of the evidence for overlap among unexplained clinical conditions. *Ann Intern Med.* 2001;134(9 pt 2):868-881.
55. Aaron LA, Burke MM, Buchwald D. Overlapping conditions among patients with chronic fatigue syndrome, fibromyalgia, and temporomandibular disorder. *Arch Intern Med.* 2000;160:221-227.
56. Aaron LA, Herrell R, Ashton S, et al. Comorbid clinical conditions in chronic fatigue: a co-twin control study. *J Gen Intern Med.* 2001;16:24-31.
57. Aaron LA, Arguelles LM, Ashton S, et al. Health and functional status of twins with chronic regional and widespread pain. *J Rheumatol.* 2002;29:2426-2434.
58. Bracha HS, Garcia-Rill E, Mrak RE, Skinner RD. Post-mortem locus coeruleus neuron count in three American veterans with probable or possible war-related PTSD. *J Neuropsychiatry Clin Neurosci.* In press.
59. Andreasen NC. Acute and delayed posttraumatic stress disorders: a history and some issues [editorial]. *Am J Psychiatry.* 2004;161:1321-1323.
60. Rounsaville BJ, Alarcon RD, Andrews G, Jackson JS, Kendell RE, Kendler K. Basic nomenclature issues for DSM-V. In: Kupfer DJ, First MB, Regier DA, eds. *A Research Agenda for DSM-V.* Washington, DC: American Psychiatric Association; 2002:1-29.
61 Pitman RK, Sanders KM, Zusman RM, et al. Pilot study of secondary prevention of posttraumatic stress disorder with propranolol. *Biol Psychiatry.* 2002;51:189-192.
62. Raskind MA, Peskind ER, Kanter ED, et al. Reduction of nightmares and other PTSD symptoms in combat veterans by prazosin: a placebo-controlled study. *Am J Psychiatry.* 2003;160:371-373